D E C L A R A T I O N

I, SHINICHI USUI, a Japanese Patent Attorney registered No. 9694, of Okabe International Patent Office at No. 602, Fuji Bldg., 2-3, Marunouchi 3-chome, Chiyoda-ku, Tokyo, Japan, hereby declare that I have a thorough knowledge of Japanese and English languages, and that the attached pages contain a correct translation into English of the priority documents of Japanese Patent Application No. 10-024370 filed on February 5, 1998 in the name of CANON KABUSHIKI KAISHA.

I further declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that wilful false statements and the like so made, are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such wilful false statements may jeopardize the validity of the application or any patent issuing thereon.

Signed this 11th day of December, 2000

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PATENT OFFICE
JAPANESE GOVERNMENT

This is to certify that the annexed is a true copy of the following application as filed with this office.

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[Title of the Invention] Solar Cell Module and Method of Dismantling the Same

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Specification

[TITLE OF THE INVENTION]

Solar Cell Module and Method of Dismantling the Same

[WHAT IS CLAIMED IS]

[Claim 1]

A solar cell module comprising a substrate, a sealant, a photovoltaic element and a protective layer, characterized in that at least one of said substrate, sealant, photovoltaic element and protective layer is separable from other constitutional members.

[Claim 2]

The solar cell module according to claim 1, which is separable into a laminate including the photovoltaic element, and the substrate.

[Claim 3]

The solar cell module according to claim 1, which is separable into a laminate including the photovoltaic element, and the protective layer.

[Claim 4]

The solar cell module according to claim 1, which further comprises an exfoliative layer.

[Claim 5]

The solar cell module according to claim 4, wherein

said exfoliative layer comprises a thermoplastic resin.

[Claim 6]

The solar cell module according to claim 5, wherein said thermoplastic resin is of non-crosslinking.

[Claim 7]

The solar cell module according to claim 4, wherein said exfoliative layer comprises a degradable resin.

[Claim 8]

The solar cell module according to claim 4, said exfoliative layer comprises a foam or a foam precursor.

[Claim 9]

A method of dismantling a solar cell module having a substrate, a sealant, a photovoltaic element and a protective layer, the method comprising separating at least one of said substrate, sealant, photovoltaic element and protective layer from other constitutional members.

[Claim 10]

The method of dismantling said solar cell module according to claim 9, comprising the step of heating said solar cell module.

[Claim 11]

The method of dismantling said solar cell module according to claim 9, comprising the step of heating and moistening said solar cell module.

[Claim 12]

The method of dismantling said solar cell module according to claim 9, wherein said solar cell module has an

exfoliative layer and the constitutional members are separated by fracturing said exfoliative layer.

[Claim 13]

The method of dismantling said solar cell module according to claim 12, comprising the step of irradiating said exfoliative layer with electron beam.

[Claim 14]

The method of dismantling said solar cell module according to claim 12 wherein said solar cell module has a foam precursor and is heated to foam the foam precursor, thereby forming the exfoliative layer.

[Claim 15]

The method of dismantling said solar cell module according to claim 9, comprising the steps of separating the protective layer and/or the substrate of said solar cell module, and then removing the sealant remaining the surface and/or back surface of the photovoltaic element.

[Claim 16]

The method of dismantling said solar cell module according to claim 15, wherein said step of removing the sealant is carried out using an acid, an alkali or an organic solvent.

[DETAILED DESCRIPTION OF THE INVENTION]

[0001]

[Field of the Industrial Utilization]

The present invention relates to a solar cell

module comprising at least a substrate, a sealant, a photovoltaic element and a protective layer.

[0002]

[Prior Art]

In recent years, solar cell modules are used in various purposes, one of which is a construction material integral type solar cell module comprising photovoltaic elements provided on a roofing steel sheet and covered with a sealant. In future, solar cell modules may become useless because of reconstruction of houses provided with solar cell modules as construction materials, or it may become necessary that they are reroofed or exchanged because of corrosion of metal substrates as a result of outdoor long-term service or because of cracks produced in surface members on the light-receiving side. Thus, when solasr cell modules having become useless are discarded, we are anxious about environmental pollution unless individual constituent members are separated from one another and sorted so as to be discarded properly, and it has become required for solar cell modules to be separable by individual constituent members. From the viewpoint of ecology, it is also required for them to be dismantled into utilizable members and to be reused.

[0003]

[Problems to be solved by the Invention]

In the prior art, no proposal has been made on a specific method by which solar cell modules are dismantled

into reusable members. The present invention provides a solar cell module from which reusable members can be separated and a method for dismantling such a solar cell module.

[0004]

[Means for solving the Problems]

The present invention provides a solar cell module comprising a substrate, a sealant, a photovoltaic element(s) and a protective layer, characterized in that at least one of said substrate, sealant, photovoltaic element and protective layer is separable from other constitutional members.

[0005]

(Operation)

(1) Even in the case that a problem occurred by any possibility in any member in its use due to a long-term outdoor use, the member can be separated and the usable residual members can be recovered and reused.

(2) Since the substrate can be separated from the solar cell module disposed for reason of corrosion of the substrate made of metal or breakdown of the substrate made of glass, the solar cell module can be reused by using a fresh substrate.

(3) Since the protective layer can be separated from the solar cell module disposed for scratches or the like of the protective layer, the solar cell module can be reused by providing a fresh protective layer.

(4) Each member can be easily separated from the solar cell module by a given treatment by providing an exfoliative layer at a desired position.

(5) By the exfoliative layer comprising a thermoplastic resin, the solar cell module can be separated into a laminate including the protective layer and the photovoltaic element, and the substrate.

(6) By providing a degradable resin layer as the exfoliative layer, the upper members and the lower members inserted with the exfoliative layer can be easily separated. For example, the degradable resin layer can be destroyed by irradiating electron beam or by biochemical destruction as another method.

(7) By providing a foam as the exfoliative layer, the upper members and the lower members inserted with the foam can be easily separated. For example, since the foam has a small adhesion area to the adjacent member and a low adhesion force, exfoliation at the interface is easy. Since gas is included in the foam also, aggregation destruction in the foam is easy. By these methods, the upper members and the lower members inserted with the foam can be separated.

[0006]

[Mode for carrying out the Invention]

A solar cell module used in the present invention will be described below with reference to (a) and (b) of Fig. 1. (a) of Fig. 1 illustrates a film type solar cell module in which a transparent film is used at the outermost

surface. (b) of Fig. 1 illustrates a glass type solar cell module in which a glass sheet is used at the outermost surface. Reference numeral 101 denotes a photovoltaic element (in plurality); 102, a surface-side sealant; 103, a protective layer; 104, a back-side sealant; 105, a back insulating material; and 106, a supporting substrate (a back member). As the photovoltaic element (in plurality) 101, conventionally known photovoltaic elements may appropriately be used.

[0007]

(Surface-side Sealant 102)

The surface-side sealant 102 is necessary for covering unevenness of the photovoltaic elements 101, protecting the photovoltaic elements 101 from severe external environment such as temperature changes, humidity and impact and also ensuring adhesion between the protective layer 103 and the photovoltaic elements 101. This surface-side sealant 102 is required to have weather resistance, adhesion, fill performance, heat resistance, cold resistance and impact resistance. Resins that can meet these requirements may include polyolefin resins such as ethylene-vinyl acetate copolymer (EVA), ethylene-methyl acrylate copolymer (EMA), ethylene-ethyl acrylate copolymer (EEA) and butyral resin, urethane resins, and silicone resins. In particular, EVA is a resin used preferably as a resin for solar cells. This EVA may preferably be cross-linked beforehand so as to have a higher thermal resistance

because EVA has a low heat distortion temperature as it is. As cross-linking agents used in such an instance, known organic peroxides may be used, any of which may be added in an amount of from 0.5 to 5 parts by weight based on 100 parts by weight of the resin. The surface-side sealant 102 may preferably be cross-lined by at least 70%. On the other hand, the sealant may be an exfoliative layer. In the crosslinked sealant, also it preferably has such properties that it softens by heat of 200°C or higher. More preferred is a sealant which, once it softens, comes to have a low adhesion to a constituent member adjoining to the sealant. Use of such a sealant makes it possible to separate constituent members by heating, between the constituent members interposing the sealant. Specific materials therefor may include polyolefin resins such as ethylene-vinyl acetate copolymer (EVA), ethylene-methyl acrylaste copolymer (EMA), ethylene-ethyl acrylate copolymer (EEA) and butyral resin, and ionomer resins.

[0008]

(Protective Layer 103)

The protective layer 103 is required performances for ensuring long-term reliability during outdoor weathering of the solar cell module, including weather resistance and mechanical strength. Materials for this protective layer 103 may include fluororesins, acrylic resins, poly(vinyl fluoride) resin (PVF), poly(ethylene terephthalate) (PET) and nylon. Stated specifically, in

the case of a film type solar cell module, it is preferable to use poly(vinylidene fluoride) resin (PVDF), poly(vinyl fluoride) resin (PVF) or tetrafluoroethylene-ethylene copolymer (ETFE); and, in the case of a glass type solar cell module, poly(vinyl fluoride) (PVF) as having a high weather resistance.

[0009]

The above resin sheet may be used as the protective layer, or a liquid containing the above resin may be coated to form the protective layer.

[0010]

(Back Insulating Material 105)

The back insulating material 105 is necessary for keeping electrical insulation between the photovoltaic elements 101 and the exterior. Preferable materials are those having sufficient electrical insulating properties, having a superior long-term durability, able to withstand thermal expansion and thermal shrinkage, and having a flexibility also. Materials preferably usable may include nylon, poly(ethylene terephthalate) (PET) and polycarbonate (PC).

[0011]

(Back-side Sealant 104)

The back-side sealant 104 can make the photovoltaic elements 101 adhere to the back insulating material 105. Materials therefor may include thermoplastic resins such as EVA, ethylene-methyl acrylate copolymer (EMA), ethylene-

ethyl acrylate copolymer (EEA) and poly(vinyl butyral), and epoxy adhesives having a flexibility, and of which may preferably be in the form of a double-coated tape. The back-side sealant 104 also may function as the exfoliative layer similar to the surface-side sealant 102 described above.

[0012]

(Supporting Substrate 106)

The back-side member 106 is bonded to the back-side sealant 104 for increasing the mechanical strength of the solar cell module, or preventing its distortion and curvature caused by temperature changes and producing a roofing material integral type solar cell module. As the supporting substrate 106, preferred are, e.g., coated steel sheets such as aluminum-coated galvanized steel sheets or galvanized steel sheets, covered with resins having superior weather resistance and rust resistance, and structural materials such as plastic sheets and glass-fiber-reinforced plastic sheets. In particular, as the coated steel sheets, preferably usable are those in which a hydrated chromium oxyhydroxide layer is provided between the steel sheet and the coating film for the purpose of rust-resisting treatment. This is because, under severe heated and moistened conditions, e.g., under conditions of 150°C and 100%RH (relative humidity), hydrated chromium oxyhydroxide melts out and becomes deposited to form a vacancy between the steel sheet and the coating film. Such

a vacant layer between the steel sheet and the coating film may be utilized to separate the constituent members.

[0013]

In the case of the glass type solar cell module, a glass substrate may preferably be used.

[0014]

(Surface Protection Reinforcing Material 107)

The surface protection reinforcing material 107 may specifically include glass-fiber nonwoen fabric, glass-fiber woven fabric and glass fillers. In particular, it is preferable to use glass-fiber nonwoven fabric.

[0015]

The step of lamination to form the solar cell module will be described below.

[0016]

(Lamination)

To produce the film type solar cell module by lamination, the supporting substrate 106, the back-side sealant 104, the back insulating material 105, the back-side sealant 104 are superposed in this order, and then the photovoltaic elements 101 are laminated thereon with their light-receiving sides up. Further thereon, the surface protection reinforcing material 107, the surface-side sealant 102 and the protective layer 103 are superposed in this order. A lamination structure thus formed may be heated and contact-bonded by means of a conventionally known vacuum laminator. The heating temperature and

heating time at the time of the contact bonding may be determined so that the cross-linking reaction of the sealant resin may proceed sufficiently.

[0017]

The solar cell module thus produced is dismantled by separating any desired constituent members at their interface. Methods therefor may include a method in which the constituent members are separated by heating, a method in which they are separated by heating and moistening, a method in which they are separated by boiling, and a method in which the solar cell module is immersed in a solvent to cause the sealant to swell to effect separation. In particular, the separation by heating and the separation by heating and moistening may preferably be used. As an example of the dismantling method of the present invention, a method in which constituent members having EVA are separated will be described below, giving an example in which EVA is used as the sealant of the solar cell module.

[0018]

(1) Separation of constituent members by heating:

The lamination to produce the solar cell module is commonly carried out at a temperature in the range of from 100 to 180°C, and preferably from 120 to 160°C. This is because, if the temperature is below 100°C, the EVA can not melt well, in other words, can not provide a good fluidity, so that the unevenness on the photovoltaic elements can not be filled up, and also, if it is asbove 180°C, there is a

possibility that the solder used to make connection between photovoltaic elements and their connection with bypass diodes masy melt to cause faulty electrical connection. In addition, solar cell modules may come to have a module surface temperature of 85°C during sunshine. In order to achieve long-term reliability for 20 years or longer in such environment, materials having substantially a resistance to heat of about 120°C are used as the EVA used in solar cell modules. Accordingly, in order to cause the EVA to soften so as to decrease the adhesion to the adjoining other constituent members, the EVA is heated to 130°C or above, during which an external peel force may be applied between the constituent members interposing the EVA, whereby the constituent members can be separated from the solr cell module with ease. In an instance where the exfoliative layer comprises a thermoplastic resin or the sealant has a low thermal resistance, the heating temperature for exfoliating may be set lower.

[0019]

(2) Separation of constituent members by heating and moistening:

EVA hydrolyzes under heated and moistened conditions of, e.g., 150°C and 100%RH. As a result of hydrolysis, the EVA decreases in its adhesion to the constituent member such as the supporting substrate or the protective layer. This decrease in adhesion of the EVA to other constituent member is utilized so that a desired

constituent member can be separated from a solar cell module. Needless to say, the higher the values for temperature and humidity conditions are, the more the hydrolysis is accelerated. Application of pressure to the atmosphere also accelerates the progress of water into the solar cell module. Such pressure may preferably be applied under conditions of at least 2 atmospheric pressure, and more preferably at least 5 atmospheric pressure.

[0020]

According to the present invention, any of the above methods makes it possible to separate the protective layer 103, the surface protection reinforcing material 107 and the back insulating material 105 and thereafter to remove the surface-side sealant 102 or back-side sealant 104 remaining on the surface or back of the photovoltaic elements 101, so that only the photovoltaic elements 101 can be reused. According to the present invention, it is also possible to separate resin masterials from metal materials to discard them. It is still also possible to remove the sealant resin such as EVA remaining on the surfaces of the photovoltaic elements, which can be removed using an acid such as nitric acid, or an alkali or organic solvent, heated to, e.g., 50°C or above.

[0021]

(Exfoliative Layer)

Provision of the exfoliative layer to the above mentioned solar cell module makes possible to separate

constituent members with ease. An exfoliative layer preferably usable will be described below.

[0022]

A thermoplastic resin may be provided as the exfoliative layer. This enables easy separation of constituent members by heating. As the thermoplastic resin, the same resin as the resin used in the surface-side sealant may preferably be used. Taking account of reuse of the constituent members obtained by separation, it is preferable not to apply stress such as heat history as far as possible when the constituent members are separated by heating. Stated specifically, a thermoplastic resin which does not cross-link may be used to provide the exfoliative layer, whereby the constituent members can be separated at a temperature lower than the instance where the constituent members are separated at the part of the sealant. In the case where the thermoplastic resin is provided as the exfoliastive layer, the constituent members can be separated at a temperature of 150°C or below. For example, when non-crosslinked EVA is provided as the exfoliative layer, the constituent members can be separated at a temperature of from 100 to 120°C. Transparent thermoplastic resins such as EVA can be provided at any position because it by no means lowers the quantity of electricity generation of the solar cell module even when provided on the photovoltaic elements. In order to ensure the long-term reliability, an ultraviolet light absorber, a

photostabilizer and an antioxidant may also be added as in the case of the surface-side sealant.

[0023]

An instance where the degradable resin is provided as the exfoliative layer will be described below.

[0024]

Resins can be degraded (broken down) by a method including electron beam irradiation and biochemical means. Herein, degradation of resin by electron beam irradiation will be described, as being preferably usable. Electron beam are included in ionizing radiations, and are one of particle energy rays which excite organic materials to ionize them. Electron beam can be controlled by adjusting accelerating voltage, radiation dose, radiation dose rate and so forth. Electron beam are applied to the solar cell module on its light-receiving side to cause molecular chains in the resin to cut to degrade the resin. Thus, the constituent members can be separated with ease between constituent members interposing the electron beam degradable resin layer thus degraded. Resins readily degradable by electron beam irradiation may include those having a chemical structure wherein ($-CH_2-CR_1-R_{2n}-$) or -CO- is repeated structurally. Stated specifically, resins having the structure of the repeating unit ($-CH_2-CR_1-R_{2n}-$) may include polyisobutylene, polymethylstyrene, polymethacrylate, polymethacrylonitrile and poly(vinylidene chloride). Resins having the structure of the repeating

unit -CO- may include polycarbonate (PC), polyacetal and cellulose. The above resin may be provided at any desired position. In the case where it is provided on the light-receiving side of the photovoltaic elements, it should be a transparent resin. In order to improve weather resistance, an ultraviolet light asbsorber and an antioxidant may also be added as in the case of the surface-side sealant. As methods for providing the electron beam degradable resin layer, the above resin may be coated on the part where constituent members are to be separated, e.g., on the supporting substrate. Alternatively, a film formed of the above resin may be provided at the part. The accelerating voltage necessary for electron beam to be transmitted through a substance becomes greater in inverse proportion to the specific gravity the substance has. For example, in order for electron beam to be transmitted through a metal member having a specific gravity of 8, it is necessary to apply an accelerating voltage eight times that necessary for them to be transmitted through a resin having a specific gravity of 1. Accordingly, in the present invention, in an instance where the electron beam degradable resin layer is provided on the back of the photovoltaic elements, it is necessary to apply an accelerating voltage of at least 500 keV in order for electron beam to be transmitted through the photovoltaic elements to degrade the exfoliative layer on the back. This makes it necessary to provide large-scale equipment.

In order to separate constituent members in relatively simple equipment, the degradable resin layer may preferably be provided on the photovoltaic elements in the case where the constituent members are separated at the exfoliative layer by electron beam irradiation. Taking account of the reuse of the photovoltaic elements separated, the electron beam may preferably be applied at an accelerating voltage of 300 keV or below. As another structure, a foam formed when the solar cell module is dismantled by heating may be used as the exfoliative layer. The foam can be formed by a chemical process in which a foam precursor prepared by mixing a resin and a blowing agent is heated to produce cells in the resin by the action of the decomposed gas of the blowing agent, or a physical process in which an inert gas is enclosed in the resin.

[0025]

First, a method will be described in which the foam is provided in the solar cell module by the chemical process.

[0026]

The foam precursor is provided in the solar cell module, between its constituent members to be separated, and, when the constituent members are separated, the foam precursor is heated to make the blowing agent decompose to form the foam by the action of the decomposed gas. The foam precursor has a large area of adhesion to the adjoining constituent members and hence has also a great

adhesion, thus the foam precursor by no means causes any peeling at the interface between it and the consituent members. However, upon blowing, the area of adhesion to the constituent members adjoining to the foam formed becomes small abruptly to cause a decrease in adhesion, thus it becomes easy to separate the constituent members at their interfaces to the exfoliative layer. Also, since the interior of the foam has come to have a small cohesive force because of the cells mixedly present, it is easy to cause cohesive failure in the interior of the foam by external peel force. Further addition of heat enables more easy separation.

[0027]

For the purpose of maintaining the quality of the foam and preventing the interior of cells in the foam from sweating because of temperature changes, the step of forming the foam may most preferably be so provided as to blow the foam precursor immediately before the constituent member are separated. Also, the blowing agent is required to have such heat decomposition properties that it is not decomposed at heating temperature at the time of the lamination for producing the solar cell module, i.e., at lamination temperature, but expands at heating temperature for separating the constituent members, i.e., at a temperature higher than the lamination temperature. For example, the blowing agent may include those having a decomposition temperature of 200°C or above, specifically

including trihydrazinotriazine, p-toluenesulfonyl semicarbazide and 4,4'-oxybisbenzenesulfonyl semicarbazide.

The resin in which the blowing agent is mixed is required to have a long-term reliability like other constituent members until the constituent members are right about to be separated, and is also required to have an adhesion strength between it and the supporting substrate adjoining to the foam precursor or between it and the sealant. As specific materials, it may include natural rubber, styrene-butadiene rbber, chloroprene rubber, ethylene-propylene-diene rubber, and copolymers of ethylene with acrylic esters, such as ethylene-vinyl acetate and ethylene-ethyl acrylate copolymers.

[0028]

A foam may be subjected to moistureproofing or waterproofing treatment on its surroundings so that a foam having already been formed can be provided in the solar cell module. At the time the laminate is produced by lamination, the foam precursor may be superposed at the desired position so that it is blown by the heat in the step of lamination to provide the foam in the solar cell module. As a blowing agent used in such an instance, it may include inorganic blowing agents such as sodium bicarbonate, ammonium bicarbonate and ammonium carbonate, and organic blowing agents such as nitroso compounds and sulfonic acid hydrazide compounds.

[0029]

The foam may also be disposed at any desired position of the laminate, followed by lamination to provide it as the exfoliative layer of the solar cell module.

[0030]

Such a foam can be formed by a method including a chemical means and a physical means.

[0031]

The chemical means is the same as the blowing means making use of the blowing agent described above. The physical means will be described below. The physical means is a method of forming a foam by injecting a gas into a resin. The resin used is required to have such a heat resistance that it does not melt by the heat applied in the step of lamination. Stated specifically, it may include poly(ethylene terephthalate), poly(ethylene naphthalenedicarboxylate), polyether sulfonate, polyimide, polyimide-amide and polyether imide. The gas to be mixed may preferably be an inert gas such as nitrogen. The gas may be mixed into the resin by a known process such as cavity mixing or nozzle mixing. The solar cell module having such a foam can be dismantled by heating the solar cell module so that the resin used in the foam is caused to melt or soften to break the foam by the aid of pressure of the gas enclosed therein, thus the constituent members interposing the exfoliative layer can be separated.

[0032]

The foam or the foam precursor may be disposed

between any constituent members. However, when the foam precursor is colored or the foam has a high opacity, incident light decreases and power generation is reduced if the foam or its precursor is provided on the photovoltaic elements. Accordingly, it may preferably be provided on the back of the photovoltaic elements.

[0033]

[Examples]

[Example 1]

Photovoltaic elements and other constituent members were laminated by the following lamination process to obtain a film type solar cell module.

[0034]

(Lamination)

On a plate of a laminator of a single vacuum system, a galvanized steel sheet (thickness: 0.4 mm) as a supporting substrate 206, an EVA sheet (thickness: 225 μm) as a back-side sealant 204, a poly(ethylene terephthalate) film (thickness: 100 μm) as a back insulating material 205 and the same back-side sealant 204 as the above were superposed in this order and then photovoltaic elements 201 were put thereon with their light-receiving sides up. Further thereon, glass-fiber nonwoven fabric (basis weight: 80 g/m^2) as a surface protection reinforcing material 207, an EVA sheet (thickness: 460 μm) as a surface-side sealant 202 and an ETFE film (thickness: 50 μm) as a protective layer 203 were superposed in this order. Thus, a

lamination structure was prepared. The EVA sheet used here was a sheet used widely as a sealant for solar cells, comprising EVA resin (vinyl acetate content: 33%) in 100 parts by weight of which 1.5 parts by weight of 2,5-dimethyl-2,5-bis(t-butylperoxy)hexane as a cross-linking agent, 0.3 part by weight of 2-hydroxy-4-n-octoxybenzophenone as an ultraviolet light absorber, 0.1 part by weight of bis(2,2,6,6-tetramethyl-4-piperidyl) sebacate as a photostabilizer, 0.2 part by weight of tris(mononony1phenyl) phosphite as an antioxidant and 0.25 part by weight of γ-mechacryloxypropyltrimethoxysilane as a silane coupling agent were compounded. Next, a Teflon coated fiber sheet (thickness: 0.2 mm) and a silicone rubber sheet (thickness: 2.3 mm) were superposed on the lamination structure. Then, the inside of a laminator was evacuated for 30 minutes to a degree of vacuum of 2.1 Torr by means of a vacuum pump. The heating temperature and heating time at the time of contact bonding were so set that the cross-linking reaction of the EVA resin proceeded sufficiently, where the laminator kept evacuated using the vacuum pump was put into an oven heated previously to have an atmosphere of 160°C and was kept there for 50 minutes. Thereafter, the laminate thus produced was taken out and cooled to obtain a solar cell module.

[0035]

(Separation)

The solar cell module was heated to 200°C, and a

mechanical exfoliative force was applied between the supporting substrate 206 and the back-side sealant 204 while making the surface- and back-side sealants melt, thus a laminate 208 having the photovoltaic elements was separated from the supporting substrate 206. Next, an external exfoliative force (2) was applied between the protective layer 203 and the surface-side sealant 202, thus the protective layer 203 was separated from the laminate 208 having the photovoltaic elements.

[0036]

[Example 2]

As follows, an exfoliative layer 309 was provided on a protective layer 303.

[0037]

(Formation of exfoliative layer)

An acrylic resin coating material (35 parts by weight of an acrylic resin composed chiefly of methacrylate, 3 parts by weight of γ-glycidoxypropyltrimethoxysilane and 62 parts by weight of xylene) was coated on the protective layer 303 by means of a spray coater so as to have a thickness of 20 μm, and the wet coating formed was natural-dried at room temperature for 30 minutes to remove the solvent, followed by force-drying at 120°C for 30 minutes to form a protective layer having an exfoliative layer.

[0038]

A solar cell module was obtained in the same manner

as in Example 1 except that the protective layer 303 was so superposed that the exfoliative layer 309 was on the side of a surface-side sealant 302.

[0039]

(Separation)

The solar cell module was irradiated by electron beam of 300 keV in a total dose of 50 Mrad on the light-receiving side of the solar cell module. Thereafter, external exfoliative force was applied between the protective layer 303 and surface-side sealant 302 interposing the exfoliative layer 309, thus the protective layer 303 was separated from the laminate 310 having the photovoltaic elements.

[0040]

[Example 3]

A solar cell module was obtained in the same manner as in Example 1 except that a foam precursor sheet formulated as shown below was superposed as an exfoliative layer, between a supporting substrate and a back-side sealant.

[0041]

(Foam precursor sheet)

100 parts by weight of ethylene-vinyl acetate resin (vinyl acetate: 15% by weight: melt flow rate: 9 dg/min), 40 parts by weight of soft calcium carbonate (primary pasrticle diameter: about 3 μm) as a nucleating agent, 5 parts by weight of trihydrazinotriazine as a blowing agent,

1 part by weight of dicumyl peroxide as a cross-linking agent, 0.5 part by weight of stearic acid and 0.1 part by weight of carbon black as a pigment were mixed, and a sheet of 0.5 mm thick was prepared by means of an inverted L four-roll calender.

[0042]

(Separation)

The solar cell module was heated at 200°C for 1 hour. Thus, a solar cell module having an exfoliative layer, a foamed sheet, with a thickness of 1.2 mm was obtained. The module was broken at the part of the exfoliative force, thus a laminate having the photovoltaic elements was separated from the supporting substrate.

[0043]

[Example 4]

A solar cell module was obtained in the same manner as in Example 1.

[0044]

(Separation)

The solar cell module was stored in an environment of 150°C, 100%RH and 5 atm pressure for 10 hours. Next, a mechanical exfoliative force was applied between the supporting substrate and the back-side sealant, thus a laminate having the photovoltaic elements was separated from the supporting substrate. Thereafter, an external exfoliative force was applied between the protective layer and the surface-side sealant, thus the protective layer was

separated from the laminate having the photovoltaic elements.

[0045]

[Effect of the Invention]

In a solar cell module according to the present invention, if by some chance a problem on product use has occurred at some place as a result of long-term outdoor service, only the constituent member(s) having caused the problem can be separated and the usable members can be recovered and reused. Also, since the exfoliative layer may be formed of a thermoplastic resin, the laminate portion can be separated from the supporting substrate by heating. In addition, since the exfoliative layer may be provided as a degradable resin layer or a foam, the constituent members can be sepasrated with ease by a given means.

[BRIEF DESCRIPTION OF THE DRAWINGS]

[Fig. 1]

(a) of Fig. 1 is a cross-sectional view of a film type solar cell module of the present invention.

(b) of Fig. 1 is a cross-sectional view of a glass type solar cell module of the present invention.

[Fig. 2]

Fig. 2 illustrates a method of dismantling a solar cell module by heating according to the present invention, as shown in Example 1.

[Fig. 3]

Fig. 3 illustrates a method of dismantling a solar cell module with an exfoliative layer 309 by electron beam according to the present invention, as shown in Example 2.

[Fig. 4]

Fig. 4 illustrates a method of dismantling a solar cell module with a foam precursor sheet 407 by heating according to the present invention, as shown in Example 3.

[Description of Reference Numerals or Symbols]

100 ... incident light

101, 201, 301, 401 ... photovoltaic elements

102, 202, 302, 402 ... surface-side sealant

103, 203, 303, 403 ... protective layer

104, 204, 304, 404 ... back-side sealant

105, 205, 305, 405 ... back insulating material

106, 206, 306, 406 ... supporting substrate

107, 207, 307 ... surface protection reinforcing material

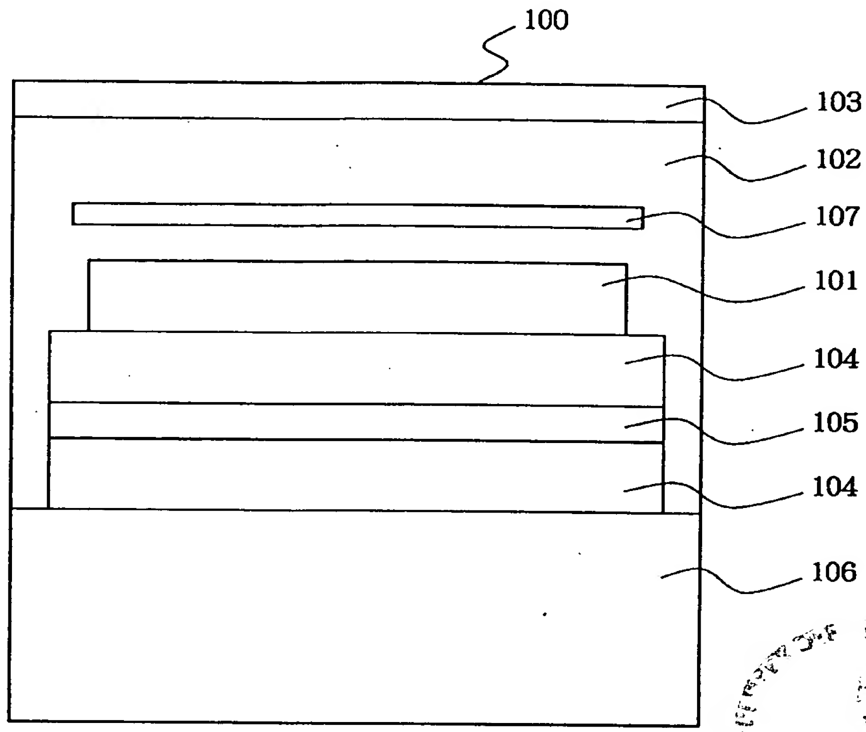
208, 310, 408 ... laminate

309 ... exfoliative layer

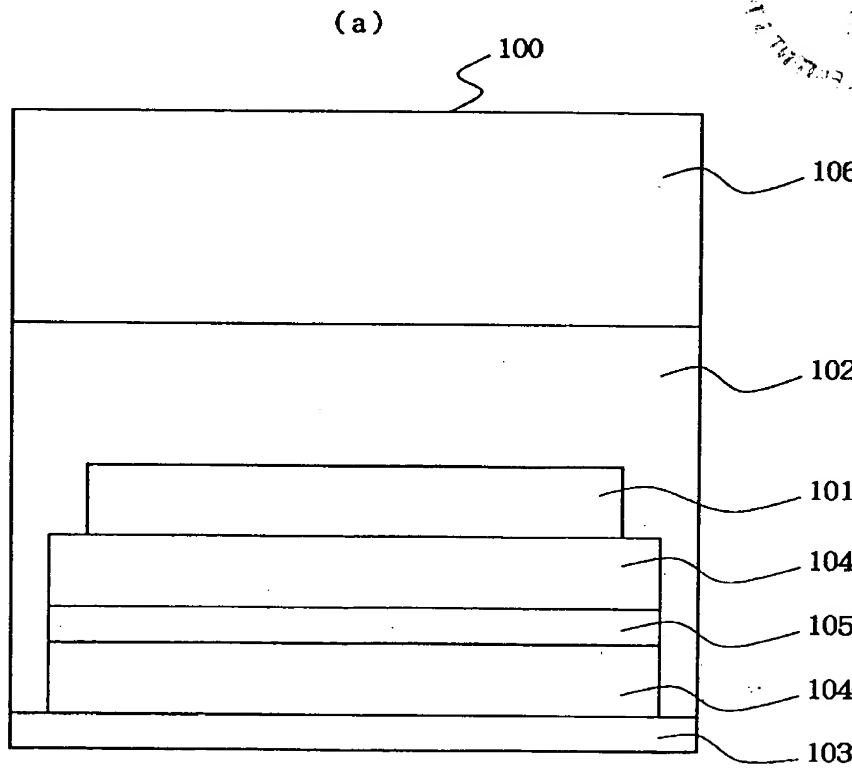
407 ... foam precursor sheet

【書類名】　図面

【図１】

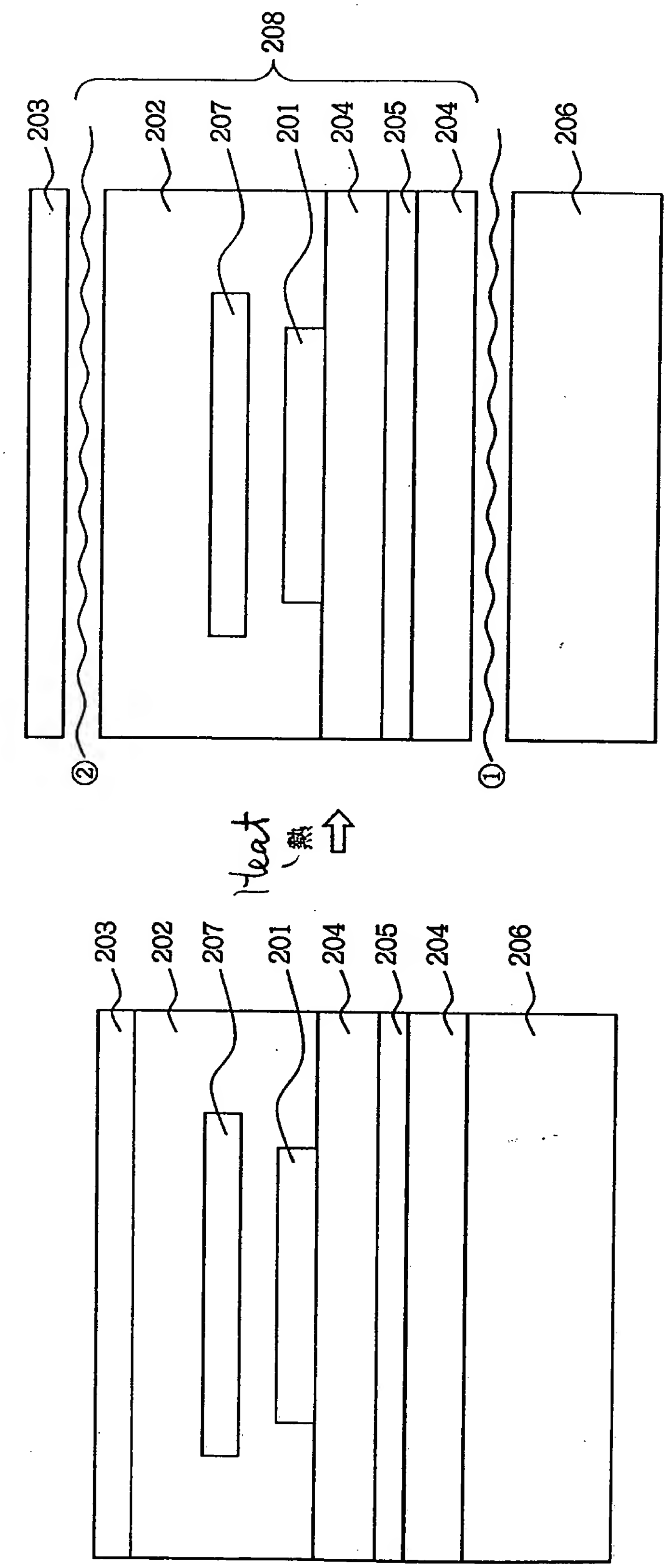

100
103
102
107
101
104
105
104
106

（a）

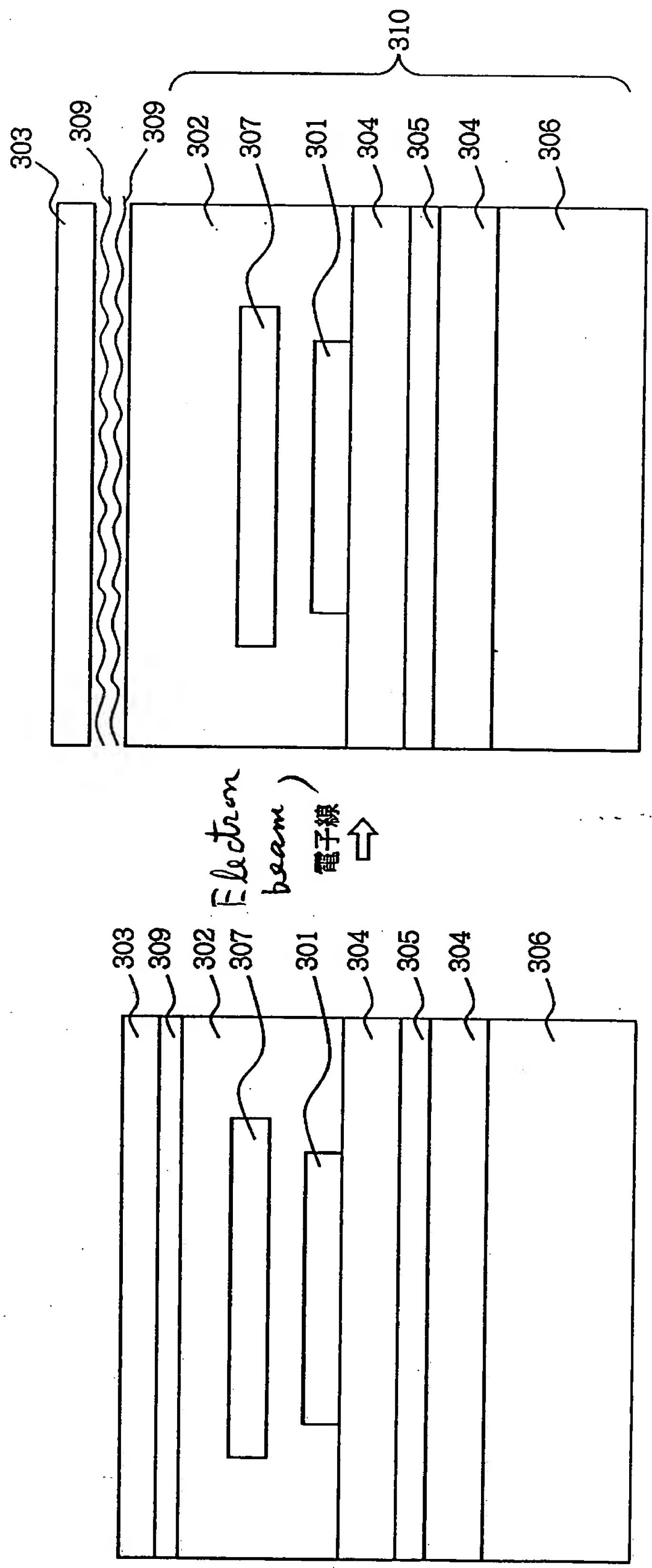

100
106
102
101
104
105
104
103

（b）

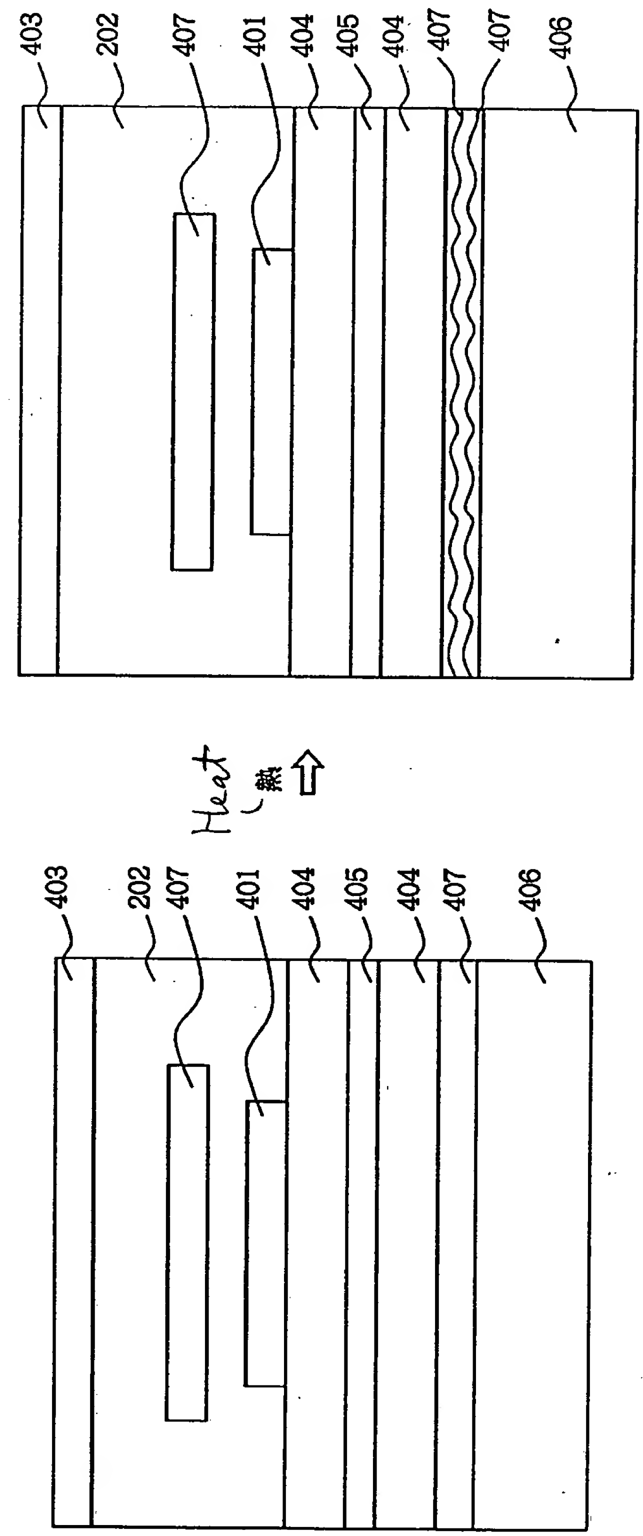
【図２】 Fig. 2


208
203
202
207
201
204
205
204
206
②
①
Heat
熱
203
202
207
201
204
205
204
206

【図３】 Fig. 3


310
303
309
309
302
307
301
304
305
304
306
Electron beam
電子線
303
309
302
307
301
304
305
304
306

【図４】 Fig.4


403
202
407
401
404
405
404
407
407
406
Heat
熱
403
202
407
401
404
405
404
407
406

[NAME OF THE DOCUMENT] Abstract

[Abstract]

[Problem]

Providion of a solar cell module in which reusable constitutional members can be separated and a method for dismantling the solar cell module.

[Means for solving the Problem]

A solar cell module comprising a substrate 206, a sealant 202, a photovoltaic element(s) 201, and a protective layer 203, characterized in that at least one of said substrate, sealant, photovoltaic element(s) and protective layer can be separated from other constitutional members.

[Elected Drawing] Fig. 2